(Parkinson et al. 1999). ''Area'' is a more precise measure of the areal extent of the ice itself, since it takes into account the fraction of leads (linear openings or cracks in the ice) within the ice, but ''extent'' is more reliably observed (Zhang and Walsh 2006). The following sections discuss specific aspects of observed sea ice changes of relevance to polar bears.

Summer Sea Ice

Summer sea ice area and sea ice extent are important factors for polar bear survival (see ''Polar Bear-Sea Ice Habitat Relationships'' section). Seasonal or first-year ice that remains at the end of the summer melt becomes multi-year (or perennial) ice. The amount and thickness of perennial ice is an important determinant of future sea ice conditions (i.e., gain or loss of ice) (Holland and Bitz 2003; Bitz and Roe 2004). Much of the following discussion focuses on summer sea ice extent (rather than area).

Prior to the early 1970s, ice extent was measured with visible-band satellite imagery and aircraft and ship reports. With the advent of passive microwave (PM) satellite observations, beginning in December 1972 with a single channel instrument and then more reliably in October 1978 with a multi-channel instrument, we have a more accurate, 3-decade record of changes in summer sea ice extent and area. Over the period since October 1978, successive papers have documented an overall downward trend in Arctic sea ice extent and area. For example, Parkinson et al. (1999) calculated Arctic sea ice extents, areas, and trends for late 1978 through the end of 1996, and documented a decrease in summer sea ice extent of 4.5 percent per decade. Comiso (2002) documented a decline of September minimum sea ice extent of 6.7 percent plus or minus 2.4 percent per decade from 1981 through 2000. Stroeve et al. (2005) analyzed data from 1978 through 2004, and calculated a decline in minimum sea ice extent of 7.7 percent plus or minus 3 percent per decade. Comiso (2006, p. 72) included observations for 2005, and calculated a per-decade decline in minimum sea ice extent of up to 9.8 percent plus or minus 1.5 percent. Most recently, Stroeve et al. (2007, pp. 1–5) estimated a 9.1 percent per-decade decline in September sea ice extent for 1979–2006, while Serreze et al. (2007, pp. 1,533–1,536) calculated a per-decade decline of 8.6 percent plus or minus 2.9 percent for the same parameter over the same time period. These estimates differ only because Serreze et al. (2007, pp. 1,533–1,536) normalized the trend by the 1979–2000 mean, in order to be consistent with how the National Snow and Ice Data Center [1] calculates its estimates (J. Stroeve, in litt. to the Service, November 2007). This decline translates to a decrease of 60,421 sq km (23,328 sq mi) per year (NSIDC Press Release, October 3, 2006).

The rate of decrease in September sea ice extent appears to have accelerated in recent years, although the acceleration to date has not been shown to be statistically significant (C. Bitz, in litt. to the Service, November 2007). The years 2002 through 2007 all exceeded previous record lows (Stroeve et al. 2005; Comiso 2006; Stroeve et al. 2007, pp. 1–5; Serreze et al. 2007, pp. 1,533–1,536; NSIDC Press Release, October 1, 2007), and 2002, 2005, and 2007 had successively lower record-breaking minimum extent values (*http://www.nsidc.org*). The 2005 absolute minimum sea ice extent of 5.32 million sq km (2.05 million sq mi) for the entire Arctic Ocean was a 21 percent reduction compared to the mean for 1979 to 2000 (Serreze et al. 2007, pp. 1,533–1,536). Nghiem et al. (2006) documented an almost 50 percent reduction in perennial (multi-year) sea ice extent in the East Arctic Ocean (0 to 180 degrees east longitude) between 2004 and 2005, while the West Arctic Ocean (0 and 180 degrees west longitude) had a slight gain during the same period, followed by an almost 70 percent decline from October 2005 to April 2006. Nghiem et al. (2007) found that the extent of perennial sea ice was significantly reduced by 23 percent between March 2005 and March 2007 as observed by the QuikSCAT/SeaWinds satellite scatterometer. Nghiem et al. (2006) presaged the extensive decline in September sea ice extent in 2007 when they stated: ''With the East Arctic Ocean dominated by seasonal ice, a strong summer melt may open a vast ice-free region with a possible record minimum ice extent largely confined to the West Arctic Ocean.''

Arctic sea ice declined rapidly to unprecedented low extents in summer 2007 (Stroeve et al. 2008). On August 16–17, 2007, Arctic sea ice surpassed the previous single-day (absolute minimum) record for the lowest extent ever measured by satellite (set in 2005), and the sea ice was still melting (NSIDC Arctic Sea Ice News, August 17, 2007). On September 16, 2007 (the end of the melt season), the 5-day running mean sea ice extent reported by NSIDC was 4.13 million sq km (1.59 million sq mi), an all-time record low. This was 23 percent lower than the previous record minimum reported in 2005 (see Figure 3) (Stroeve et al. 2008) and 39 percent below the long-term average from 1979 to 2000 (see Figure 4) (NSIDC Press Release, October 1, 2007). Arctic sea ice receded so much in 2007 that the so-called ''Northwest Passage'' through the straits of the Canadian Arctic Archipelago completely opened for the first time in recorded history (NSIDC Press Release, October 1, 2007). Based on a time-series of data from the Hadley Centre, extending back before the advent of the PM satellite era, sea ice extent in mid-September 2007 may have fallen by as much as 50 percent from the 1950s to 1970s (Stroeve et al. 2008). The minimum September Arctic sea ice extent since 1979 is now declining at a rate of approximately 10.7 percent per decade (Stroeve et al. 2008), or approximately 72,000 sq km (28,000 sq mi) per year (see Figure 3 below) (NSIDC Press Release, October 1, 2007).

[1] The NSIDC is part of the University of Colorado Cooperative Institute for Research in Environmental Sciences (CIRES), is funded largely by the National Aeronautics and Space Administration (NASA), and is affiliated with the National Oceanic and Atmospheric Administration (NOAA) National Geophysical Data Center through a cooperative agreement. A large part of NSIDC is the Polar Distributed Active Archive Center, which is funded by NASA.